Parking Lot Landscaping Guidelines

Guidelines for
Parking Lot Design,
Shading Requirements &
Maintenance

City of Sunnyvale
April 2002

Parking Lot Landscaping Guidelines

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City of Sunnyvale, California

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INTRODUCTION & SCOPE OF BOOK

Introduction

In the mid-nineteenth century Sunnyvale began as small town serving a large agricultural community. Prior to Silicon Valley was Blossom Valley. From Palo Alto to south San Jose were thousands of acres of orchards and farms. Urbanization began in earnest in 1955 when Lockheed Corporation moved to north Sunnyvale adjacent if Moffett Naval Air Station. Orchards gave way to subdivisions. Along with subdivisions came more industry, more roads and streets, more shopping centers, strip malls. With the increase in people came the increased dependence on the automobile. To accommodate the influx of people and their cars came the need for lots of parking.

Significant portions of commercial and industrial developments are covered with asphalt to accommodate the need for the parking of cars. Little attention has been paid to the significant influence that large areas of asphalt paving have on the environment. In the 1950's and 1960's most parking lots were contiguous seas of asphalt, interrupted only by parking lot lighting fixtures. In the 1970's emphasis was placed on landscaping and living plant materials as a required part of commercial development. Also this time, nationwide, were the start of the environmental movement and the Environmental Protection Agency. The impact that mankind is having on the planet has been studied. Many local, state and federal laws, have been enacted to mitigate the negative influences of humans on the environment. Large paved areas, especially black asphalt, have a tremendous influence on the environment. They contribute significantly to creation of 'heat islands', stormwater runoff, and pollution of surface runoff water. The City of Sunnyvale recognizes the need for parking lots but also recognizes that such parking lot can be designed and created to be much more environmentally friendly as well as more pleasant places for cars and people.

Guiding Principles and Performance Requirements

This publication describes the elements of a well-designed parking lot. Various layout and landscape design ideas are presented to assist in complying with the City of Sunnyvale Municipal Code. The design techniques and suggestions are intended to give the designer ideas on how to comply with the Sunnyvale codes. Other techniques may be used to accomplish the performance standards. Also, as an "all-in-one place" reference, parking lot development code requirements are provided in this booklet. Please verify with staff that the standards are current.

PARKING LOT LANDSCAPING STANDARD REQUIREMENTS

The City of Sunnyvale Municipal Code Section 19.38.070. *Landscaping, irrigation and usable open space,* includes the following standard parking lot landscaping requirements.

- Parking lot landscaping is required for all zoning districts. A minimum of 20% of the parking lot area must be landscaped, and this amount may count towards the total landscaped area.

- Landscape and irrigation plans shall be prepared by a registered architect, landscape architect, licensed landscape contractor, licensed nurseryman or other similarly qualified person.

Tree Survey Requirement:

- Tree surveys are required for all development projects where the site contains non-orchard trees. The tree survey must be conducted by an arborist who has been certified by the International Society of Arboriculture. The survey shall show:
  - ⇒ Location, size and species of all non-orchard trees on site
  - ⇒ Calculation of the value of each tree
- A letter explaining why a protected tree (a tree greater than 38 inches in circumference when measured at 4 ft. from ground level) is proposed to be removed and why it cannot be relocated.

Tree Protection Plan Requirement:

- The developer shall submit a tree protection plan to safeguard the health of protected trees during construction. This plan shall consist of a minimum of a 5 ft. high fence to be installed along the dripline of each protected tree.

Layout Requirements:

- Landscape areas and parking islands shall be designed to integrate parking lot and site drainage in order to reduce storm water runoff velocities and minimize non-point source pollution.

- Landscape islands with trees shall be a minimum of 5 ft. x 5 ft. excluding curbs.

- A 15 ft.-wide landscape strip is required along the entire frontage of a lot, measured from the inside edge of the public sidewalk. If no sidewalk exists, the strip is measured from the curb. The landscape strip may contain sidewalks and be crossed by access drives and parking areas. When existing conditions preclude the 15 ft. landscape strip and the area inside the walk is less than 6 ft. in width, a hedge, wall, berm, or raised planter of at least 30 inches in height must be provided.
- A six-inch poured in place concrete curb with drainage "weep holes" shall separate landscaping from parking areas.
- Concrete wheel stops, properly installed with epoxy and metal dowels, are required when curbing does not adequately protect landscape areas.

Buffer Landscaping Between Non-Residential and Residential Uses:

- Buffer shall maintain a minimum width of at least ten feet.
- Buffer shall include a decorative masonry wall six feet in height measured from the highest adjoining grade. Where a residential use is permitted in a nonresidential zoning district, the wall shall be required on the residential property, unless a wall is already existing.
- Buffer shall include a planted screen of approved trees and shrubs.

Planting Requirements:

- Trees shall be planted and maintained throughout any surface parking lot to ensure that, within 15 years after establishment of the parking lot, at least 50 percent of the parking area will be shaded. *See Shading Calculation Chapter….*
- 70% of all planting species shall be water-conserving plants. (*See Water Conserving Plants document– Ask a Planner)*
- Trees shall be of minimum fifteen gallon size.
- Shrubs shall be at minimum five gallon size; accent or ground cover shrubs may be one gallon size.
- Living ground cover shall be installed twelve inches on center.

- Trees at twenty-four inches or thirty-six inches box may be required to meet part of the tree requirements. There shall be one tree per three hundred square feet of required landscape area in addition to required street trees and parking lot trees.
- There shall be two shrubs per three hundred square feet of required landscape area excluding the required parking lot landscape area.
- There shall be mulch at two inches in depth added to all nonturf soil areas.
- Nonporous materials shall not be placed under plants or mulched areas.
- Installed trees shall have two stakes that are:

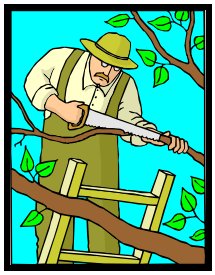
  A. At least 2.5 inches in diameter;
  B. Same height as the tree prior to installation;
  C. Installed at least 2.5 feet into the ground;
  D. Attached to the tree in at least two places.

- Annual color or water intensive landscaping shall be confined to high visibility and/or high pedestrian use areas.
- Non-water-conserving plants shall be grouped to allow more effective irrigation.
- All turf areas shall be planted with fescue or similar turf requiring less water. No turf shall be on mounding with slopes greater than ten percent.
- Landscape areas and parking islands, with or without trees, shall contain living ground cover or shrubs, unless it can be shown that ground cover is incompatible with the tree. Where living ground cover is unsuitable, the director of community development may allow porous, nonliving ground cover such as pebbles or tanbark.

Irrigation Requirements:

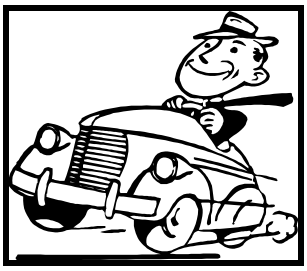
- All required landscaped areas shall be provided with a permanent irrigation system.
- Bubbler or drip type irrigation shall be provided for trees and shrubs. Overhead irrigation systems may be used for clustered shrub plantings.

- Valves and control circuits shall be separated based on required rate and quantity of water used. Serviceable check valves are required where differences in elevation may cause drainage to low elevation sprinklers.
- Irrigation plans shall indicate the monthly irrigation schedule for each irrigation circuit for one year following the plant establishment period.
- Sprinkler heads must have matched precipitation rates within each circuit.
- All new systems must have automatic controllers capable of dual or multiple programming.
- Controllers and backflow devices shall be screened from public view.
- Systems shall be designed to meet the individual needs of each plant group.
- Systems shall incorporate a rain shutoff device and battery backup.



Maintenance Requirements:

- After landscaping is installed, it shall be maintained in a neat, clean and healthful condition.
- Landscaping removed due to disease or death of plants shall be replaced to match the approved landscape plan.
- Landscaping installed per approved plan which is removed without approval of the city, and which cannot be demonstrated to have been diseased or dead, shall be replaced with specimen plants to match the approved plan.



Minimum Stall Dimensions:

For C-1, C-2, C-3 and O zoning districts as well as for restaurants, retail sales, medical or dental facilities and offices in any zoning district:

- **9' x 18'.**

All other zoning districts and uses not listed above:

- **8.5' x 18'.**
- Compact space: **7.5' x 15'**

The 18 ft. length may be reduced to 16 ft. when there is an interior landscaping island of 6 ft. in width or a perimeter landscaping strip of greater than 4 ft. in width.

Minimum Back-Up Distance

- 24 ft. for residential uses
- 26 ft. for all other uses

Minimum Driveway Width

Parking not served by an aisle shall be served by driveways complying to the following minimum standards:

- One-Way Driveway – 10 ft. for residential uses and 12 ft. for all other uses
- Two-Way Driveway – 18 ft. in residential zones and 20 ft. in other zones.

All uses requiring more than 15 parking spaces shall be served by 1 two-way driveway or 2 one-way driveways, including adequate turn-around areas.

PARKING LOT SHADE REQUIREMENTS

Parking Lot Shading Requirement

The Sunnyvale Municipal Code states:

Trees shall be planted and maintained throughout the lot to ensure that at least fifty percent of the parking area will be shaded within fifteen years after the establishment of the lot. Shading shall be calculated by using the diameter of the tree crown at fifteen years. All surfacing on which a vehicle can drive is subject to the shade calculation, including all parking stalls; all drives within the property, regardless of length, and including drive-through lanes: and all maneuvering area, regardless of depth.

Parking Lot Shading Goals

Although the Municipal Code requires that fifty percent of the parking lot surface is to be shaded within fifteen years, the goal is to achieve as much shading as possible within time. The Municipal Code sets the minimums. To achieve the parking lot shading goal several elements are required. This guideline shall discuss the elements required to make parking lot shading a reality.

Parking Lot Shading Calculation

All parking lots shall have a *Parking Lot Shading Plan*. The parking lot shading plan shall be submitted with all other required building and development plans for review and approval. This plan is typically derived using the landscape planting plans as the base. For purposes of calculation, the vertically projected tree canopy diameters shall be used for these calculations.

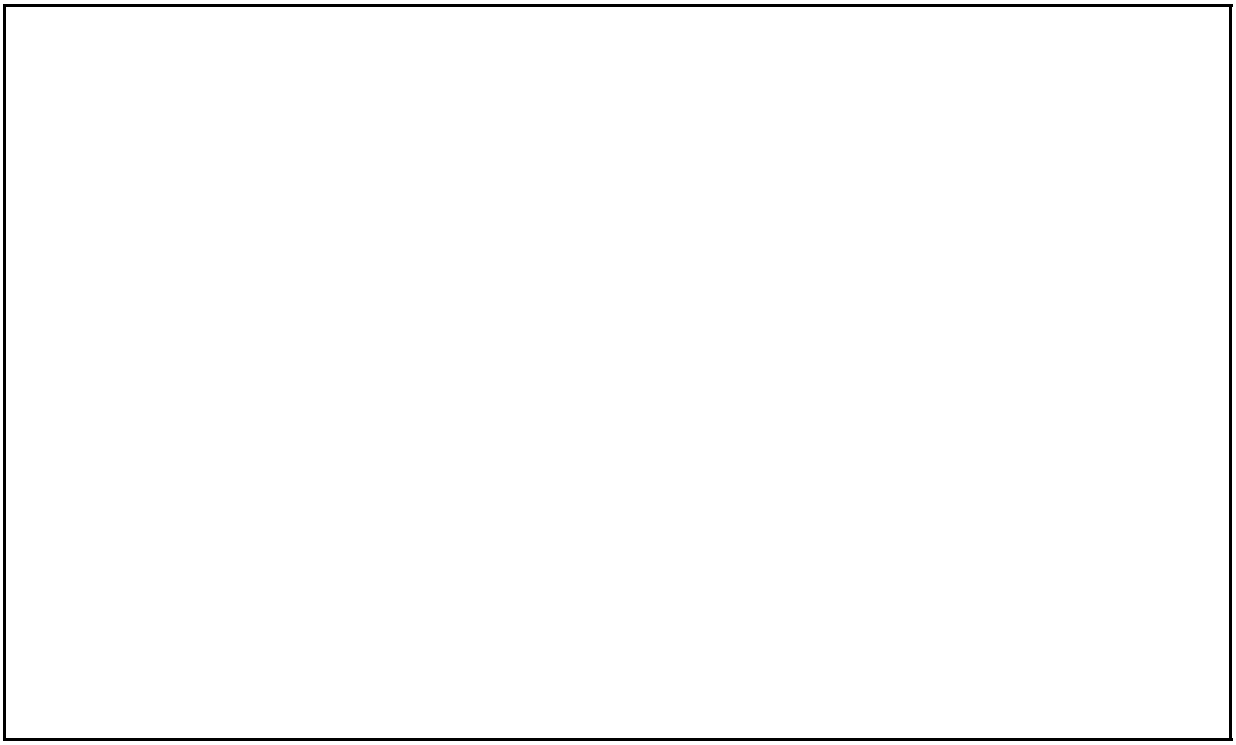
A tree's location in and around the parking lot will affect where they cast shade on the pavement. Trees shall be given full, three-quarters, one half, and one quarter credit for shading of the parking lot. Tree canopy covers that overhang planting areas, sidewalks, building roof tops and other non-paved parking area shall not be counted in the calculation. Trees planted close together that form overlapping or merged canopies are not counted twice. Areas where canopies overlap shall not be counted twice.

The parking lot shading plan shall show all tree canopies at their diameters at fifteen years after establishment of the parking lot. Pre-existing trees that are

preserved in the parking area can be included and are also subject to the shading credit calculation. Shading calculations shall be made on the diameters expected at 15 years; mature diameters shall only be allowed in the calculation if truly the trees will be that size at fifteen years.

Parking Lot Shading Plan: A parking lot shading plan shall be submitted with the landscape plans for all new and reconstructed parking lots. The plan shall clearly show all surfaced areas included in the calculation. Trees shall be drawn to scale representing the canopy size at 15 years as listed in the **Master Parking Lot Tree List.** The percentage of shade for each tree shall be clearly indicated. (refer to example 1)

Example 1:



Paved Area Calculation: All surfacing on which a vehicle is designed to maneuver shall be clearly indicated on the shading plan and the total area calculation noted in the shade calculation table. Surfacing includes all parking stalls, loading areas, drives within the property line, and areas for maneuvering. The following are not considered paved parking areas and are not required to meet the 50% shading requirement:

- Truck loading in front of overhead doors

- Truck maneuvering and parking areas unconnected to and exclusive of any vehicle parking
- Surfaced parking areas for automobile dealerships, lumber yards, and similar facilities that are used for display, sales, service, and vehicle storage. All required parking for theses uses are subject to the 50% shading requirement.

Shaded Area Calculation: Shaded parking lot area is determined by using the appropriate percentage of the crown as indicated on the approved shade list. Only trees from this list may be used as parking lot shade trees unless otherwise approved by the city's arborist. It is recommended that the genera of the trees be varied throughout the parking lot..

If a site has two or more unconnected parking areas, shade is calculated separately for each area. If they are connected by a joining drive, they are calculated as one lot.

Shaded Calculation Table: The shading plans shall also include a table identifying the quantity and type of trees used and the percentage of shade credited to each. All trees shall be from the **Master Parking Lot Tree List** and calculated with the corresponding canopy size. (see table below)

SYM	BOTANICAL NAME/COMMON NAME	FULL S.F.	3/4	HALF S.F.	1/4	TOTAL S.F.
T1	*Prunus eerasifera* Flowering Plum	1 @ 491 s.f.	2 @ 368 s.f.	3 @ 246 s.f.		1,965 s. f.
T2	*Quercus suber* Cork Oak		2 @ 722 s.f.	6 @ 481 s.f.		4,330 s. f.
T3	*Plantanus acerfolia "yarwood'* London Plane Tree		1 @ 722 s.f.	12 @ 481 s.f.	1 @ 240 s.f.	6,734 s. f.

Total Tree Shade	13,029 s.f.
Total Paved Area	24,430 s.f.
Percent Shaded	**51.2%**

The following section is the **Master Parking Lot Tree List**. This is a listing of trees suitable for use in parking lots and their associated tree canopies at fifteen years from planting at a standard fifteen-gallon container size.

MASTER PARKING LOT TREE LIST

Shade Tree Listing

The **Master Parking Lot Tree List** is a compilation of tree species and cultivars that have proven performance in the south San Francisco Bay/Sunnyvale area. This list is not all-inclusive.

For trees not on the list the Director of Community Development may approve such trees for parking lot use if certified by a California state registered landscape architect, a California certified nurseryman, the City of Sunnyvale superintendent of Trees and Landscaping, the City of Sunnyvale superintendent of Park Operations, or an International Society of Arboriculture certified arborist as to their performance.

This list identifies specific cultivars for many species. Where cultivars are listed the height, spread and water requirements are for those cultivars only. Where a tree species has many cultivars the height, spread and water requirements are given for an average range. If a particular cultivar is selected, the cultivar's height and spread characteristics shall be used if significantly different from the range given on this list (e.g. dwarf varieties shall be not be calculated at the average range size). Common names are given for reference. No common name is listed as NCN. Height at maturity is the average expected full mature height, which for most trees listed is well beyond fifteen years. Spread at maturity is the average expected at full maturity. The spread at 15 Years is a best estimate if a 15-gallon sized tree is planted, assuming best conditions. The subterranean provisions must be provided and the maintenance and irrigation practices maintain optimal growing conditions. Pruning practices must conform to sound arboricultural industry standards. Topping, shearing or heading will not provide the tree canopies needed to satisfy the shading requirement.

Code Definition

L	Low – typically a Mediterranean climate native. Once established may require only occasional summer water
LM	Low to Moderate - once established water requirements are low but weekly watering April to October maintains best growth
M	Moderate - requires weekly watering between April and October for the tree's entire life.
MH	Moderate to High - like Moderate but does better with plenty of water in the summer.
H	High – these trees are water lovers and are from high rainfall areas. Ample water needs to be available all season

Water requirement will be unique to trees in parking lots. Parking lot islands are typically limiting as to the subterranean delivery of water. Also the surrounding asphalt surfaces in parking lots increase reflected heat, increasing the tree's demand for water. These factors must be taken into consideration in the potential growth and development of parking lot trees.

Waterwise Planting List

- Water conserving plants shall be installed in 70% of all landscaped areas. A list of water conserving plant material is available at the One-Stop Counter at City Hall.

Pesticide Reduction Planting List

Plants that do not require pesticides will help reduced the introduction of pesticides into the environment (*this list to be added later when Stormwater Runoff Program provides detailed information)*

See Master Parking Lot Tree List Attachment

SUBTERRANEAN PROVISIONS FOR TREE PLANTING

Subterranean Provisions

In order to meet the parking lot shading requirements the parking lot trees need all of their biological conditions met. This includes subterranean provisions for the trees root growth and development. For trees to provide the shading required in parking lots they must get large. Those tree species with a naturally large stature at maturity must have an adequate soil environment. The soil space required for a tree of large stature is approximately twenty feet by twenty feet by three feet deep. This space can be provided at grade or below paving.

To meet the parking lot shading requirement trees must cast their shadow on the paved area. Therefore, in most instances, the paving will be close the trunks of the trees. Large open landscape areas in the parking lots are environmentally beneficial and can support very large trees but if the tree canopies do not cover the parking area, part or all of their canopies will not be counted in the shading calculation.

Current civil engineering paving standards are not compatible with tree root development. The typical parking lot profile is an asphalt wearing course over a compacted base-rock material over a compacted subgrade soil. If the parking lot is built up, the fill soil is typically compacted in lifts until the desired subgrade is achieved. This profile presents a severely compacted subterranean environment.

Typically, trees develop roots in a shallow radial pattern. Tree roots must support the live load of the tree and must be able to increase that support as the tree grows and puts higher loads on the roots. Deep taproots are the exception and when they are existent, shallow lateral roots accompany them. The photo below shows an exhumed 12-inch in diameter Ginkgo tree with lateral roots exposed. This Ginkgo has a relatively deep root system with the lateral roots radiating out at about twelve inches below the surface soil grade. There are some deeper roots, down to four feet, under this tree but there is no taproot.

When the lateral roots encounter the standard parking lot subterranean profile they either find an avenue to penetrate below the asphalt usually in the interfaces between the layers or they are bound in the tree well itself.

Where tree planting spaces do not provide adequate subterranean soil volume, special considerations must be made for tree root development below paving. Cornell University's patented 'Structural Soil' has proven performance in providing load bearing rooting space under paving.

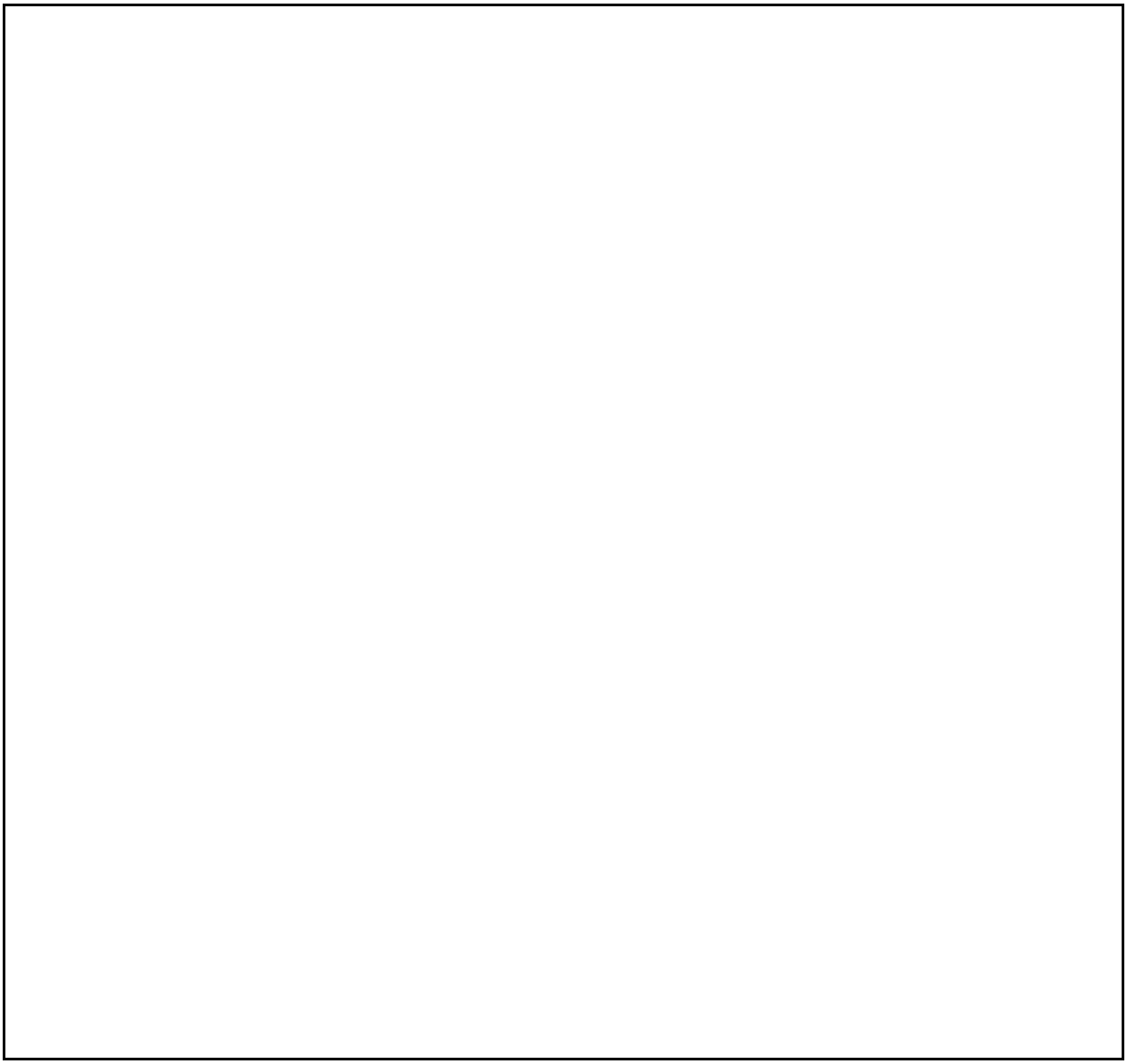
Cornell University 'Structural Soil' is a gap graded base rock material with clay loam soil component. The rock varies in size between 3/4 and 1-1/2" diameter. The rock easily compresses and in between the rock are large pores. These pores are partially filled with soil for the roots. The stone bears the load and the roots penetrate the voids for soil, water and air. Approximately one half of the pore space in the rock is filled with soil. The percentage of soil versus stone is critical to prevent the pores from being filled completely with soil. If the soil fills the voids completely, it will become compacted; thus the material will no longer benefit the tree roots.

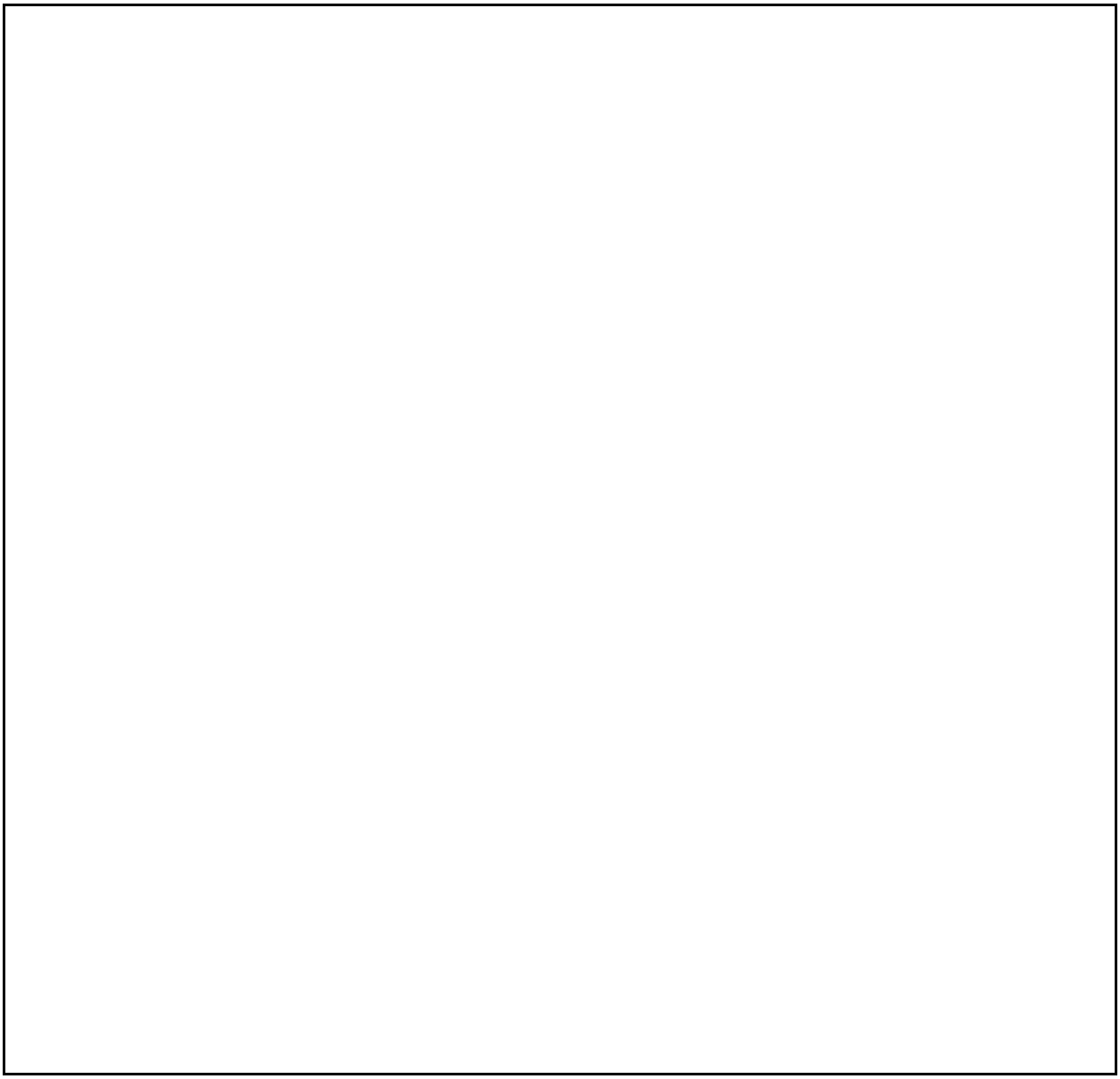
The soil is adhered to the rock by using hydrogel as a sticking agent during formulation. The rock is blended with the soil resulting in rock clothed with a layer of soil. Then the entire mix is moved to the parking lot site and installed like standard Class II base rock. The structural soil will compact to 100% Proctor Density and will typically have a California Bearing Ratio between 60 and 100. Asphalt, concrete or concrete pavers can be installed direct on top of the structural soil base rock.

Academic research and practical applications show that when tree roots encounter structural soil base rock they enter the soil in the rock matrix. The most unique phenomenon is that the roots have angled downward as the roots extend into the rock-soil mix. It appears that as a stone is encountered the root goes around it in downward motion.

The practical use of the structural soil base rock under paving is both allow for larger rooting volumes for the trees as well as avoiding tree root damage to the paving surface as the tree's root grow and develop in time. If the soil conditions eighteen inches or below from the finish grade is not unduly compacted then tree roots should penetrate the subsoil well below the asphalt. The larger the root system, the larger and healthier the trees will be; thus providing the required parking lot shading.

The following pages provide details illustrating structural soil placement.





ALTERNATIVE PAVING METHODS

Alternative Paving Methods provide an opportunity to design parking lots with permeable surfaces versus the conventional asphalt and concrete which do not allow rainwater to penetrate the surface. Other positive effects of using alternative paving methods include design and site enhancement as well as traffic calming methods.

Permeable Pavements

Permeable Pavements are a method of infiltrating stormwater while simultaneously providing a stable load-bearing surface. While forming a surface suitable for walking and driving, permeable pavements also contain sufficient void space to infiltrate runoff into the underlying reservoir base course and soil.

Pervious Concrete: Porous concrete, also known ask Portland cement pervious pavement is a discontinuous mixture of coarse aggregate, hydraulic cement and other cememtitious materials, admixtures and water, which forms a permeable pavement. Pervious concrete, like other concretes, acts as a rigid slab. It has an appearance very similar to exposed aggregate concrete, and provides a similar walking or riding surface.

Porous Asphalt: Porous asphalt consists of an opengraded asphalt concrete over an open graded aggregate base, over a draining soil. Unlike traditional asphalt concretes, porous asphalt contains very little fine aggregate (dust or sand), and is comprised almost entirely of stone aggregate and an asphalt binder, giving it the common name “popcorn mix”.

Unit Pavers on Sand

A wide variety of unit pavers are available for use in outdoor applications. Unlike poured-in-place concretes or asphalts, which create one continuous surface, unit pavers are made of discrete units that are set in a pattern on a prepared base. This gives unit pavers flexibility in design, construction and maintenance.

Turf Block: Turf block is one example of an open celled unit paver. These open celled unit pavers are available in both precast concrete or plastic, and are often filled with soil and planted with turf. When planted with turf, they are generally most successful in overflow parking areas, and driveways.

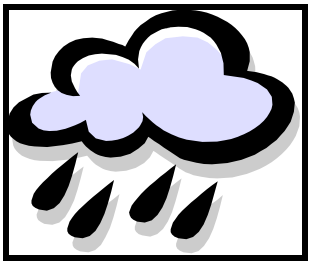
Concrete Unit Pavers: Solid precast concrete unit pavers are available in a wide variety of colors, shapes, sizes, and textures. They are designed to be set on sand, and form an interlocking pavement surface that can bear heavy traffic loads. Their permeability and performance is similar to brick on sand.

Granular Materials

A wide variety of loose porous aggregates can be made to form permeable pavements suitable for pedestrian and light vehicular traffic.

Crushed Aggregate: A wide variety of crushed aggregates, generally known as gravel, can be used to form a permeable pavement. Aggregates are available in a variety of sizes, ranging from approximately 2" to sand size grains known as "fines". Relatively inexpensive to purchase and easy to install, gravel can be laid in any shape or configuration. In selecting gravel pavements for pedestrian or vehicular traffic, crushed stones provide the most suitable surface, as the angled facets of the aggregate from an interlocking, semi-rigid matrix.

INCORPORATING STORMWATER Best Management Practices INTO PARKING LOT DESIGN



In any development, storage space for stationary cars can consume many acres of land area, often greater than the area covered by streets or rooftops. Since parking is usually accommodated on an asphalt or concrete surface with conventional underground storm drain systems, parking lots typically generate a great deal of directly connected impervious area.

There are many ways to both reduce impervious land coverage of parking areas and to filter run-off before it reaches the storm drain system.

Parking Grove: A variation on the permeable stall design, a grid of trees and bollards can be used to delineate parking stalls and create a "parking groove". A benefit of this design is that the parking grove not only shades parked cars, but presents an attractive open space when cars are absent.

Hybrid Parking Lot: Hybrid parking lots work on the principal that pavement use differs between aisles and stalls. Hybrid lots reduce impervious surface coverage in parking areas by differentiating the paving between aisles and stalls, combing impervious aisles with permeable stalls.

Overflow Parking: In some locations daily parking needs fluctuate, often with peak use occurring only for special events or seasons. Typically, parking lots must be constructed to accommodate the peak demand, generating a high proportion of impervious land coverage of very limited usefulness. An alternative is to differentiate between regular and peak parking demands, and to construct the peak parking stalls of a different, more permeable material. This "overflow parking" can be made of a turf block, which appears as a green lawn when not occupied by vehicles, or crushed stone.

Grass Swales: Parking lot drainage can be integrated with landscaping to provide infiltration and detention basins. Grass swales can be a particularly effective design strategy in large conventionally paved parking lots, by providing, low maintenance, walkable, linear biofilters along the perimeter of the lot or along internal islands. Stormwater is directed to these linear landscaped spaces travels slowly over turfgrass or other vegetative surfaces, allowing pollutants to settle and slowing runoff velocities.

Plant selection

The proper selection of plant materials can improve the infiltration potential of landscape areas. Deep rooted plants help build soil porosity. Plant leaf-surface area helps collect rainwater before it lands on the soil, especially in light rains, increasing the overall water holding potential of the landscape. This above ground surface areas created by trees and other plants greatly contributes to the water holding capacity of the land.

RETAINING EXISTING TREES

Existing Tree Preservation

New development in Sunnyvale, in most cases, is redevelopment of existing property. It is most likely that there will be mature trees existing on these properties. In the development of parking lots, the existing trees on the property shall be preserved. The site design shall consider these trees in the design and layout of the property. Preserved existing trees can be included in the parking lot shading requirement calculation.

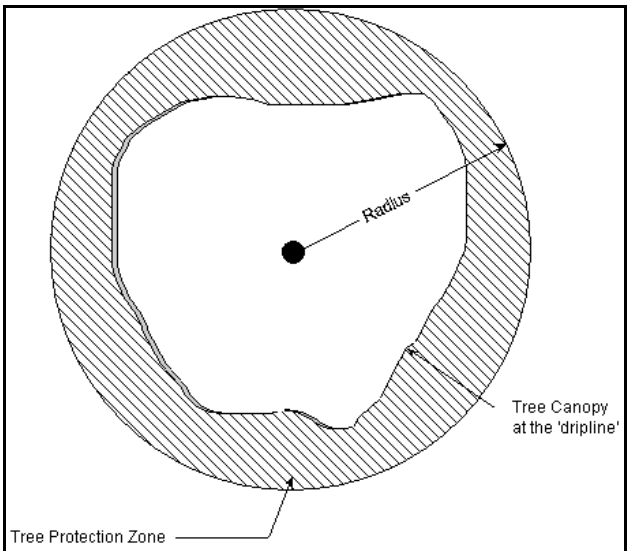
Tree Survey and Appraisal

All trees on the site shall be surveyed as to their species and location relative to the existing site. An ISA Certified Arborist or a Consulting Arborist (American Society of Consulting Arborists) shall appraise all existing trees affected by the construction activities. The appraised dollar amount of tree shall be published in an Arborist's Report. The appraisal shall conform to the latest edition of Council of Tree & Landscape Appraisers *'Guide for Plant Appraisal'* as published by the International Society of Arboricuture, Champaign, IL using the Trunk Formula Method of appraisal.

The tree survey shall be superimposed on the civil engineer's site plan. This shall be the Tree Survey Site Plan. The existing tree's canopies shall be shown on the plan. This plan shall have a legend listing all trees by their botanical and common names and their dbh (diameter at breast height- ie 4.5 feet from soil grade). The legend shall indicate which trees are to be preserved and which trees are recommended for removal. Each tree on the legend shall be indexed to a tree on the Tree Survey Site Plan.

Tree Preservation

Existing trees to be preserved need to be identified on site and on a Tree Preservation Plan. This plan shall specify the required activities to protect and preserve existing trees during the entire site development process. Trees to be preserved need also be identified on any site demolition plans, grading plans, and site utility plans and on those plans shall reference the Tree Preservation Plan as to preservation requirements.



Tree Protection Zone

An experienced arborist, horticulturist or landscape architect in tree root development and mature tree preservation shall identify the Tree Protection Zone(s) for trees to be preserved. A tree protection zone is an area of land around a tree, typically measured as a radius around the tree's trunk, which no excavation, grading or trenching activity can occur. The most commonly used limit for the tree protection zone is the tree's 'dripline' or canopy. This may be a good 'rule of thumb' but should not be used where tree damage will occur if dripline is used. The British Standards Institute set guidelines for tree protection zones for trees with average to excellent health and vigor as follows:

Species Tolerance	Tree Age	Distance from trunk per unit tree diameter (Ft. radius per In. diameter)
GOOD	Young Tree (<20% of life)	0.5
	Mature Tree	0.75
	Overmature (>80% of life)	1
MODERATE	Young Tree (<20% of life)	0.75
	Mature Tree	1
	Overmature (>80% of life)	1.25
POOR	Young Tree (<20% of life)	1
	Mature Tree	1.25
	Overmature (>80% of life)	1.5

The Tree Preservation Plan shall show the trees being preserved with their existing canopies illustrated, the tree protection zone, the tree location relative to the proposed site development plan, and elevation at the root crown (where the tree trunk enters the soil).

Tree Protection

Trees that have been identified as to be preserved need care and protection. Tree care of existing trees should continue from the existing use of the property through all development stages of the project up to occupancy and beyond.

Trees shall have fencing installed around them at the periphery of the tree protection zone. Fencing shall be chain link type. Support posts shall be driven into the soil to discourage removal or relocation of the fencing. On the fencing shall be signage around the periphery identifying the tree as a protected tree and stating the limits of the tree protection zone. Also on the signage identify whom to contact if one needs further information regarding the tree protection plan requirements. It is recommended that a professional tree care or landscape contractor care for preserved trees during the construction. A source of potable water must be available to irrigate the preserved trees as needed. Trees not near a water source will require the importation of water for irrigation.

Locating Tree Roots

The most common construction conflicts involve grading and paving and utility line installation. Being that tree roots are shallow, vertical trenching will sever tree roots.

Utility lines that must past through a tree protection zone should be bored underneath the tree's root system. Typically borings thirty-six inches or more below the trees finish grade will not damage the tree's root system. If boring is not possible or practical then the tree's roots need to be located. There are two methods used to remove soil around roots without damaging them.

There is hydraulic excavation and pneumatic. Hydraulic excavation requires high-pressure water and a sewer-vacuuming device. The pneumatic process requires an air compressor and a gun with a special nozzle that allows for supersonic (1,400-mph) air to dislodge soil. Both methods leave roots intact.

Once identified, the roots can be protected during excavation. Being that the roots are still living they need to be covered with wetted burlap during the excavation process. As soon as the utility line is installed, the soil around the roots needs to be restored, covering the exposed roots.

Grade Changes and Paving over Roots

Being that tree roots are shallow, they are significantly impacted by grade changes. Excavation or lower the soil grade around a tree will remove most of its roots. Grades around trees must be such that the existing roots will not be excavated. Raising the grade over existing tree roots is more feasible than lower the grade. If the grade is lowered then the entire tree protection zone must be left intact. If this is in a large landscape area then lowering the grade is feasible. If lower the grade will be in the tree protection zone then tree damage will occur.

Paving over existing tree roots is possible if the subgrade of the paving begins at or above the tree's existing finish grade. Structural soil base rock or gap graded base rock can be used over the top of the existing roots. The base rock depth should be sufficient that will allow a minimum of compaction of the soil. Deep fills, ie greater than two feet, usually will cause problems with the natural water and soil air exchange process. Deep fills are discouraged.

Construction Plans Coordination

All construction plans that can affect the preserved trees need coordination of the various architects, engineers and other designers in order to avoid conflicts. The primary plans that will routinely require coordination are grading and paving plans and utility plans. The engineers need to know of the existence of trees to be preserved in order not to create a conflict between the preserved tree's requirements and their design requirements. Also landscape architects and irrigation designers need to be included. Landscape contractors are not immune to causing tree root damage with irrigation installation.

LONG TERM MAINTENANCE OF PARKING LOT LANDSCAPES

To be effective the landscaping in the parking lots will require routine care. If the plant species selection, soil condition, and irrigation system have be well designed and installed, the landscape maintenance should go easy. Therefore, long term maintenance begins with a good design and good installation. Defects in the design and/or installation typically cannot be made up with extra maintenance. To satisfy the parking lot shading requirement will require diligence in the care of the parking lot trees.

Irrigation Design

Irrigation begins with the design of the landscape. Different plant material will have differing watering requirements. Shallow roots plants such as turfgrasses (6"± deep) require more frequent watering and excellent coverage. Most groundcovers have deeper roots but are still relatively shallow (12" or less). Shrubs and trees have deeper roots than lawns and groundcovers but they shallow relative to their size. Even the largest trees, one will find most of the roots in the top three feet of soil with small feeder roots within inches of the soil surface.

The irrigation design must match the plant materials needs. Lawns will require the best coverage. Turfgrass do not have interconnecting vessels. Essentially lawns are thousands of individual grass plants growing tightly together. If the irrigation coverage is poor, you will get 'dry spots' where the coverage in less than the grass needs in that location. The typical maintenance solution is to increase the watering to get the 'dry spots'. This means that the rest of the lawn is being overwatered and water is wasted. Overwatering can cause problem is making the lawns too wet for use, saturating the soil causing oxygen deprivation, disease problems, and outright runnoff which can pollution problems as well as just wasting the water.

Groundcovers are more forgiving as to irrigation coverage than lawns but will need good coverage in the initial establishment period. The same is true for trees and shrubs. They need good coverage in the establishment period but can get by on less than perfect coverage as time goes on.

Your irrigation design is done for the most demanding plants in the landscape planting. Trees in lawns will have irrigation designed for the lawn's needs. Irrigation of trees and shrubs in groundcovers need to meet the needs of the groundcovers. In areas with only trees or shrubs will have to meet the needs

only of the most needy plants in the landscape.

For parking lots the irrigation also needs to be designed to irrigate only landscape areas and avoid paving that runs off to storm drains. Also cars and pedestrians need to be considered. Pop-up sprinkler heads are required in parking lots to avoid damage by cars and being tripping hazards to pedestrians.

Intelligent irrigation is designed into circuits that all have the same sprinkler head type. Also the irrigation system need a controller-timer system that allows watering at different frequencies and durations depending on irrigation demand for each circuit.

There are numerous irrigation system components that deliver water. There are stationary spray heads, single and multi-stream rotor heads, flood bubbler heads and drip irrigation. Like tires on your car these types of sprinkler heads should not be mixed on the same circuit. Each type of head has it specific water delivery specifications. Stationary spray heads typically deliver from one to two inches of water over their spray pattern per hour. Where as stream rotor heads deliver from one-half to one inch per hour. Mixing head types will either over or underwater somewhere on that irrigation circuit. Flood bubblers will flood a small area. The delivery rate for bubblers is gallons per minute (1-2). The irrigation pattern is very close to the irrigation head and relies on some time period to flood a defined small area. Bubblers typically need to be in small, flat planters where the water will flood the area without draining away. Bubbler work best in tree wells that only have one single tree in it i.e. like under a tree grate.

Drip irrigation is a special case. In most cases drip irrigation needs to be on its own controller-timer. The water delivery is measured in gallons (½ to 3) per hour. The water literally drips out of the drip heads (emitters). This is similar to flood bubbler but the rate of delivery is low enough that the water infiltrates the soil without any runoff even on slopes. The irrigation is designed by the irrigation pattern of the drip emitter. Usually the pattern in loam soil is a foot in diameter and as deep as the water will penetrate over time. Drip irrigation is typically used to irrigate specific plants. The drawback to drip irrigation is that the water delivered stays in a small area and if the pattern of emitters does not allow for future plant root growth plants will stay small and will not grow to their intended size. While drip irrigation works well in a container tree nursery, it is inefficient for irrigating large trees.

Drip irrigation is recommend in these guidelines for delivering water to structural soil baserock under paving. The water delivery is low and will not flood the ground below the paving. The pattern does not be perfect but just enough to provide moisture to tree roots that occupy the structural soil baserock zone.

Irrigation Operation

Assuming the irrigation system is designed and installed properly, its operation is crucial to the maintenance of the landscape. Irrigation demand is a function of the plant species demand, the soil volume occupied by plant roots, and the season climatic demand. Hopefully the irrigation circuits have similarly demanding plants on them. The sunny sides of buildings are on different circuits that the shady sides. The irrigation timing is set for the most needy plant species, water wise, on that circuit.

Water demand is a function of the soil volume occupied by plant roots the water holding capacity of the soil and the season climatic demand. As a landscape becomes established and begins to mature plant roots will occupy larger soil volumes. This means that water can be applied less frequently by filling the larger rooted soil volume with water and allowing the plants to use the water over time. When two plant species with very different root volumes are mixed, ie turf and trees, the irrigation frequency is a function of the plant with the smallest rooting volume.

The seasonal climatic demand is directly functional to day length. The highest demand will be on the longest days of the year; peaks on June 20th. The climatic demand has some modifiers. One is the sun. When it is cloudy demand is moderated. When it is windy the demand is increased. Location is a factor. Heat absorbing and light reflecting areas will increase the demand. Parking lots without shading of trees have a much higher demand than standard landscape areas. Contrary to belief, high temperatures are not the driving force in plant water demand; it's the direct rays of the sun. Demand rises and falls in the day, peaking at around noon and then declining. Demand rise as the days get longer and fall as the days get shorter. Hot August and September days are not as demanding as the long days of June and July. The irrigation season the Sunnyvale area is from about April 15th to November 15th. Between November and April the days are shorter and rainfall can and does exceed demand. Many plants go dormant in the winter months dropping irrigation demand practically to zero. Usually winter rainfall is all that is necessary except where structures shadow planting areas from rainfall.

Evergreen plants still demand water on sunny winter days although the demand is very small compared to summer days.

Schedule irrigation according to the seasonal climatic demands. The most frequent irrigations will be increasing up to June 20th and then declining. Water demand is measured in inches of surface water applied. The typical demand in the Sunnyvale area in April ranges ½" to ¾" per week. May is ¾" to 1" per week. June and July the demand ranges 1" to 1-½" per week. August is 1" to ¾" per week. September is ¾" per week, and October is ¾" to ½" per week. November to April is minimal with rainfall compensating for demand.

General Landscape Maintenance

Ongoing and routine maintenance is required to properly maintain the landscaping in the parking lots. Parking lots present a harsher environment to plants in general. Reflected heat off the pavement, limited soil volumes, many times questionable soil conditions (subterranean debris, compaction, base rock, concrete spoils, variable fill soils), inadequate irrigation, heat radiating from cars (engines and radiators), various automotive fluids dripping into the soil give plant life in parking lots a tougher environment in with to grow and perform.

The most significant landscape maintenance factor is irrigation. Except during the winter rainy season, the landscape maintenance personnel have 100% control of the irrigation. The irrigation system needs to be monitored regularly. Are the irrigation circuits working properly? Are the sprinkler heads delivering water to their intended areas? The controller-timers need to be programmed to apply water in an efficient manner. Too long an irrigation cycle can apply too much water at one time and cause runoff. Too short can limit plant growth. Both wastes water. The irrigation program needs to be seasonally adjusted to compensate for seasonal demand. A summer schedule extending into the winter is not only wasteful it can saturate the soil and cause plant diseases and subterranean asphyxiation and death of plant roots.

Typically fertilization for general landscape plants in the landscape is on an as needed basis. An annual fertilization is typically all that is necessary for trees shrubs and established groundcovers. Lawns are a little different in they have a higher nitrogen fertilization need with regular mowing. If slow release type fertilizers are used, only two fertilizations per year are needed. One in the late winter (March) and in the early fall (September-October). The spring fertilization coincides with the new spring growth and the fall coincides with rapid root development and carbohydrate storage.

Typically winter fertilization will not yield a response if the grass has gone semi-dormant. Summer irrigation usual develops a lot of green growth that has to be mowed more frequently or more commonly scalped by the regular mowing schedule. Rapid growth by over-fertilization will leave the grass more susceptible to mid-summer diseases.

Tree Care

The most ecologically significant element in a parking lot landscape is the trees. If allowed to get large and shade large areas of paving they will modify the microclimate and make the whole area more livable for plants and people.

Trees for parking lot shading will most likely be large growing species. The species for parking lots need to be planned with their ultimate size in mind. Parking lot trees for shading shall be allowed to grow to there natural genetic size and habit. Parking lot shading trees shall not be pruned for size control, sign clearance, or view clearance. These factors need to be taken into consideration in the original landscape design. Trees do not get 'too tall'. Plant the right tree in the right place.

Pruning Standards

The trees installed to comply with the parking lot shading requirements shall be trained according to latest version of the following industry standards: *Tree-Pruning Guidelines, International Society of Arboriculture (ISA) 1995; American National Standard for Tree Care Operations – Tree, Shrub and Other Woody Plant Maintenance Standard Practice, ANSI A300-1995; American National Standard for Tree Care Operations –Pruning, Trimming, Repairing, Maintaining, and Removing Trees and Cutting Brush – Safety Requirements, ANSI Z133.1-1994 plus revision January 1997.*

The people training young trees as well as established and mature trees need to be arboriculturally qualified. The tree training and pruning staff should be either Certified Tree Workers, Certified Arborists or directly supervised by a Certified Arborist. These certifications are granted by International Society of Arboriculture (ISA) by the successful passage of a written and performance examination. ISA certification is maintained by approved and verified continuing education in arboriculture and tree care.

In the early years of a young tree's life pruning should be limited to structural training of the tree. It is at this time that the tree's main branches are developed. Shearing tipping and/or topping are injurious practices to all trees and are prohibited in parking lots except for trees that may be designed as special

Each tree species has specific growth habit. These habits range from upright, columnar to spreading, horizontal. Branching structure varies between single central trunk to an open multi-branched structure. Typically trees will grow into their natural genetic structural habit. But in many cases nursery grown trees may have been pruned for production and may not have the correct structure for a particular species. These structural anomalies need to be corrected at planting or in the first year after planting.

Unless specifically trained from the nursery as multi-trunked trees, most trees form a single trunk typically in their early years. A tree species with a strong central leader (single, central trunk) needs its leader kept dominant.

Branches subordinate to the central leader are called lateral branches. All lateral branches need to be smaller in diameter than the trunk and need to be radically and vertically well spaced around the trunk. The vertical spacing is a function of the tree species, the diameter and angle of attachment of the lateral branches. Ideally the lateral branches should emanate from the trunk at broad angles ie 45° to 90° to the trunk. Trees with narrow, ie less than 30°, angles of attachment tend not to have a solid attachment between the upper side of the branch and the trunk. Many times the bark of the trunk and a narrow angled branch becomes 'included' and there no attachment to the heartwood of the tree except on the bottom side of the branch. These branches can fail when they get large by splitting away from the trunk. Trees with branches forming very narrow angles need to be examined regularly during their establishment years to remove these types of branches and encourage branches with better attachments.

Tree species that form an open, broad spreading crown are quite variable in how the they exhibit their spreading habit. In many species the central leader that develops from seed loses it dominance. The lateral branches grow faster than the leader can stay ahead, giving the tree a rounded or spreading habit. Other trees will retain the central leader for there entire life but the lateral branches will grow to varying lengths over time giving the tree a spreading habit. Still other trees, the central leader is lost almost immediately, leading to multiple trunks or multiple main branches without any noticeable central trunk or leader.

In all cases trees need to be structurally pruned throughout their lives. Branches need to arise from the trunk(s) well spaced along the trunk. This also true for branches attached to lateral or scaffold branches. Branches that come out from of the trunk clustered close together cannot develop the wood that forms strong attachments. The relative size of a branch in relation to the trunk is more important for strength of the branch attachment than is the angle of attachment. One should strive to have the lateral branches, well as secondary branches arising from lateral branches be one-half or less the diameter of the trunk or lateral from which they arise.

For more specific information on young tree training see ISA publication *Tree-Pruning Guidelines.* See the Appendix for other references on tree care.

Tree Replacement

The City of Sunnyvale will inspect the parking lot landscaping for compliance to the parking lot shading requirement. Inspections shall be at two years after installation (occupancy), then at five years, ten years and fifteen years for compliance. A tree not performing as expected shall be replaced after a determination of the cause and said cause is remedied. Trees shall be replaced with incrementally larger contain grown trees depending on the years from original installation. At five years replacement trees shall be 24 inch boxed size trees. At ten years the replacement trees shall be 36 inch boxed size trees. And at fifteen years the replacement trees shall be 48 inch boxed size trees.

GLOSSARY, RESOURCES & LINKS

Glossary

Air Quality and Energy Conservation – Parking lots directly and indirectly affect air quality and energy conservation. Parking lots directly add to the heat island affect of cities. This in turn increase air temperatures that drive atmospheric smog development chemical reactions. Shading of pavement will reduce atmospheric heating. Use of trees for pavement shading is required. Parking lots indirectly affect air quality and energy conservation by allowing unshared vehicles to heat up. This causes direct volatilization of hydrocarbons out of the vehicle as well as heat up the interior of the car. Hot car interiors cause motorists to use air conditioning longer that otherwise using more fuel and contributing pollutants to atmosphere. Shading of vehicles and pavement is required to save energy and improve air quality.

Hardscape Elements- are encouraged to improve esthetics. Lighting, special-paving treatments, pedestrian corridors, decorative bollards, public art can be used to enhance the visual appearance of the parking lot.

Heat Island Mitigation – Open areas of paving, especially black asphalt, contribute to the creation of heat islands. Parking lots shall be designed to use trees to provide shading. The ultimate goal is to have 100% of all asphalt shaded but at minimum all parking stalls should be 100% shaded. Trees for the parking lots must have a mature stature to provide a substantial shade cover. Placement of trees in parking areas also shall be used to provide canopy cover. Trees do not particularly have to be down the centerline of parking bays.

Land Use Efficiency – the open space of a parcel of land shall be used efficiently. Parking lot designs should not pave over open space unnecessarily. More parking is not better. Parking shall not exceed demand. Public transportation shall be encouraged to reduce parking demand.

Maintenance Management – For the parking lots to remain functional there must be ongoing maintenance. The maintenance of the parking lots must provide care of all landscape elements. Trees are a major ecological element in parking lots. They must receive professional care by qualified arboricultural staff. Parking lot trees shall not be sheared into balls or other shapes but shall be allowed to grow to their natural size and habit..

Mature Tree Preservation – Being that nearly 100% of the City of Sunnyvale is built out, many properties are redeveloped. Redevelopment means that the site has served it purpose and the owners now are either upgrading the property or entirely redeveloping the property. Such properties typically have mature tree now existing on the site. These trees shall be conserved. This means that the existing mature trees must be considered in the redevelopment. These trees are assets in the existing Sunnyvale community urban forest. Existing trees shall be considered in the design of the parking lot. Typically mature trees are in an existing parking lot. Therefore new grades, drive lanes, parking lot configurations and orientation must take into account the existing mature trees.

All trees on a site shall be inventoried and appraised by an ISA Certified Arborist. The loss of mature trees value shall be a consideration and may require and in-lieu to compensate the City of Sunnyvale for the loss of urban forest asset.

Safety – With vehicles come drivers and passengers. When those drivers are out of their cars they become pedestrians. Provisions must be made for pedestrian movement in parking lots. Safety corridors shall be provided pedestrian to associated facilities. Parking lots shall conform to Sunnyvale traffic engineering requirements that allow for safe movement of vehicles. Public safety vehicle access and fire lanes must be provided.

Water Runoff Management – Being traditional parking lots have been designed with impermeable pavements, all surface runoff from these parking lots has flowed to storm drains. With all runoff to storm drains these traditional parking lots add tremendous amounts of particulates and surface contaminants to the stormwater runoff stream. Parking lots need to be designed to capture most of the routine runoff. Subterranean containment, pervious paving, surface infiltration systems and the like can accomplish this.

Water in parking lots typically comes from one of two sources, natural rainfall and landscape irrigation. Sunnyvale's Mediterranean climate has nearly all of the annual rainfall in the fall and winter months (November through April). Most rain events are less than one inch and spread out over days. With this rainfall pattern much water can be infiltrated in the soil if provisions are made for such. Landscape irrigation must be designed to be efficient; keeping water to within landscaped areas and avoiding overspray in paved areas.

Visual Impact – Parking lots need to be designed to de-emphasize visibility of the cars in the lot to public street. There shall be a landscape buffer between the public street and the parking lot. Berms, walls, shrubs, trees can be used to create an effective separation. Internal parking lot landscaping shall be required to soften the visual impact of the parked cars. Parking lot bay end planters shall be used to improve the aesthetic appearance of the parking lot.

Resources

City of Sunnyvale Municipal Code Chapter 19: Zoning

City of Sunnyvale Public Works Specifications Book

Bay Area Stormwater Management Agencies Association (BASMAA). *Start at the Source: Residential Site Planning and Design Guidance Manual for Stormwater Quality Protection*. BASMAA, San Francisco, CA. January 1997.

Center for Watershed Protection. *Better Site Design: A Handbook for Changing Development Rules in Your Community*. Center for Watershed Protection, Inc., Ellicott City, MD. 1998.

Schueler, Thomas R. *Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs*. Metropolitan Washington Council of Governments, Washington, DC. 1987.

Schueler, Thomas R. *Urban Runoff in the Washington Metropolitan Area.* Metropolitan Washington Council of Governments, Washington, DC. 1983.

Smith, David R. *Life Cycle and Energy Comparison of Grass Pavement and Asphalt Based on Data and Experience from the Green Parking Lot*. The Heritage Conservation and Recreation Service, Order No. A-4331-4. 1981.

Smith, David R. and Sholtis, David A. *An Experimental Installation of Grass Pavement.* The Heritage Conservation and Recreation Service, Order No. A-4331-4. 1981.

Links

City of Sunnyvale Web Site: *http://www.ci.sunnyvale.ca.us/*

Bay Area Stormwater Management Agencies Association: *http://www.basmaa.org/*

Santa Clara Valley Urban Runoff Pollution Prevention Program: *http://www.scvurppp.org/*

The Stormwater Manager's Resource Center: *http://www.stormwatercenter.net/*

The Center for Watershed Protection: *http://www.cwp.org/*